APPLICATION FOR

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of

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for

SEAL ASSEMBLY

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SEAL ASSEMBLY

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The invention relates to a seal assembly comprising a laminated structure according to the independent claim.

Brief Description of the Related Art

[0002] Modern large industrial gas turbines have a shielded combustor such as known from US-B1-6,450,762. Due to the ever greater need for efficiency and combustor stability, the arrangement requires primary to secondary air system seals to be fitted. Driven by the work on known combustor systems, the seals are become exposed to ever-higher temperatures, extending to a temperature up to 1500° C on the hot gas side. It is this thermal exposure that drives the need to define a seal assembly that can live with these temperatures while remaining resilient and responsive to system movement. Highly stressed metals are subject to severe stress relaxation at high temperatures, rendering them useless as resilient sealing elements under such conditions. Even the so called nickel based super alloys such as Inconel 718 and other materials show little ability to withstand exposure to high temperatures beyond 700°C in a stressed condition without suffering severe stress relaxation and/or creep.

[0003] Conventional solutions use cooled seals whereby substantial quantities of cooling air flow are required. This use of cooling reduces the efficiency of the gas turbine and can impair flame stability.

SUMMARY OF THE INVENTION

[0004] It is the aim of the present invention is to provide an advanced seal assembly

which remains flexible and resilient as a spring, by keeping the spring element at or near to the temperature of the cooler secondary airflow. Hence, part of the seal assembly must defined to shield the spring element without allowing heat radiation or conduction to heat the spring side support.

[0005] According to the independent claim a seal assembly was found, the seal assembly comprising a layered structure consisting of

[0006] a first layer of a base material,

[0007] a second layer of thermal insulating material on top of the first layer and

[0008] a third layer of a base material or oxidation resistant material on top of the layer of thermal insulation.

[0009] The layer of thermal insulating material can consist of a woven insulating material, whereas the first and/or third layer of base material consists of any standard seal material such as Inconel 718. A third layer exposed to a hot gas path could consists of an oxidation resistant material such as PM2000.

[0010] The layered structure can be arranged within a connector plate. The connector plate is constructed with a composite structure which removes radiation and conduction from the central connector plate to spring side support, in a way that the seal assembly remains within the temperature range of the cold gas flow and therefore advantageously flexible and actively sprung in its location during operation of the combustor. The layer of thermal insulating material is woven into strips which maybe aligned with or at a defined angle to the primary axis to ensure flexibility.

[0011] The layer of the oxide resistant material can be welded to the layer of base material of the connector plate.

[0012] In another embodiment of an inventive seal assembly, the layer of thermal insulating material is arranged between two conventional E-seals as first and third layer.

[0013] The seal assembly described herein can be a seal between combustor liner segments between combustor liner segments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Preferred embodiments of the present invention are illustrated in the accompanying drawings, in which

[0015] Fig. 1 shows a combustor liner assembly of a shielded combustion chamber of a large industrial gas turbine,

[0016] Fig. 2 illustrates the arrangement of a seal between two combustor liner segments as seen in the detail II in the Fig. 1.

[0017] Fig. 3 illustrates a seal assembly according to the present invention,

[0018] Fig. 4 illustrates the detail IV in the Fig. 3.

[0019] Fig. 5 illustrates a second embodiment of an inventive seal assembly and

[0020] Fig. 6 shows a third embodiment of an inventive seal assembly.

[0021] The drawings show only the parts important for the invention. Same elements will be numbered in the same way in different drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Fig. 1 shows a cross sectional view through a combustor liner assembly of a shielded combustion chamber 1 of a large industrial gas turbine. Over the circumference of the casing 4 of the combustion chamber 1 are arranged a plurality of combustor liner segments 2, which are fixed to clamp strips 3. As seen in detail in Fig. 2, which shows the detail II of Fig. 1, between two combustor liner segments 2 is arranged a seal 5, which is an axial combustor double E-seal. Through cooling holes 6 within the clamp strip 3 and cooling holes within the seal 5 flows a cooling medium towards the combustion chamber 1. The seal or seal assembly 5 is on a side A exposed to the hot gases of the combustion chamber 1 having a temperature of up to 1500°C and on the other side B to the cooling medium having a temperature of up to 600°C. To remain flexible and actively sprung in its location between the combustor liner segments 2, the spring side supports 7 of the seal assembly 5 must remain within the temperature of the cold gas flow.

[0023] Fig. 3 illustrates a seal assembly 5 according to the present invention The inventive seal assembly 5 comprises two spring side supports 7 and a laminated connector plate 8. The spring side supports 7 are connected to the connector plate 8 by means of welding. To remove heat radiation from the central connector plate 8 to spring side supports 7, the connector plate 8 is constructed with a composite structure as seen in Fig. 3 and 4. Thereby, Fig. 4 illustrates the detail IV of the Fig. 3.

[0024] As seen in Fig. 4 composite laminated connector plate 8 consists of three different layers 9, 10, 11. A first layer 9 of a base material or inner connector band, which can be made from a standard seal material such as Inconel 718, is responsible for the structural integrity of the seal assembly 5. Any other standard seal material may be used as well. The second layer 10 of the thermal insulating material such as Nextel or any other suitable material on top of the layer 9 of base material is made from a woven material. A third layer 11 on top of the layer 9 of a thermal insulating material can be made of a base material such as Inconel 718 as well or it can be made of an oxide resistant material from any suitable oxidation resisting material. The layer 10 of thermal insulating material is woven into strips which maybe aligned with or at a defined angle to the primary axis to ensure flexibility.

[0025] Since no data relative to radiation or forced convection is currently available, the following calculation of heat flux through the layered structure of the connector plate 8 was based on the starting assumptions noted below, for conductive heat transfer only within a seal 5 consisting of a layered structure of a first layer 9 of Inconel 718, a second layer 10 of Nextel and a third layer 11 of Inconel 718.

[0026] Assumed external skin temperature of the outer Inconel 718 ply (t_1): 1200°C

[0027] Assumed external skin temperature of the inner Inconel 718 ply (t_4): 600°C

[0028] Temperatures t_2, t_3, and heat flux are calculated by solving three simultaneous equations for equal heat flux through each layer of the sandwich (Inconel 718/Nextel/Inconel 718), which must always be true. The solution, for the assumed conditions, is 0.32 W/mm^2. This is for a single ply of Nextel high-grade (>99%) alumina (Al_2O_3) cloth, 0.28 mm thick (0.011 inch), with a 2000°C melting point and two plies of

0.20 mm thick (0.008") Inconel 718.

Coeff of thermal conductivity of Inconel 718		23.9W/mK
Coeff of thermal conductivity of Nextel		0.16W/mK

Temp of hot surface of Inconel 718 outer ply	t_1	1200°C
Temp of cool surface of Inconel 718 outer ply	t_2	1197.3°C
Temp of hot surface of Nextel	t_2	1197.3°C
Temp of cool surface of Nextel	t_3	602.7°C
Temp of hot surface of Inconel 718 inner ply	t_3	602.7°C
Temp of cool surface of Inconel 718 inner ply	t_4	600°C

Heat	t_1 to t_2	t_2 to t_3	t_3 to t_4	
Flux	0.32	0.32	0.32	W/mm^2

[0029] The Nextel is very effective in protecting the Inconel 718. However, since the coefficient of thermal conductivity of Nextel cloth is very low (approx 0.16 W/mK) compared with Inconel 718 (23.9 W/mK), care should be exercised to avoid overheating of the outer Inconel 718 layer 11 exposed to temperatures as high as 1530°C. The melting point of Inconel 718 or Haynes 25 is 1332°C approximately.

[0030] Assuming the combustion chamber 1 contains very high velocity turbulent gas flow, it may reasonably be assumed that a high rate of heat transfer exists, both as radiation from the flame and from (local) hot surfaces, as well as forced convection (if the seal 5 is in a high velocity zone and unshielded). It may therefore be assumed that the outer layer 11 of the connector plate 8 will be at temperature relatively close to the local temperature in the combustion chamber 1. Therefore it is necessary to ensure that sufficient cooling airflow in terms of supply temperature, mass flow and even distribution, exists on the cool side B of the seal 5, to dissipate the heat flux traveling through the seal 5. By so doing this will keep the cool side B of the seal 5 close to the temperature of the cooling airflow.

[0031] Since the ratio of conductivities of Nextel to Inconel 718 is 0.1/23.9, it is clear

that a very much reduced amount of cooling air is required to accommodate this greatly reduced heat flux. Herein lies the major benefit of applying an insulated seal 5. It now becomes possible to maintain the resilient sealing element at a low enough temperature to avoid stress relaxation, without incurring the cost penalty of using large amounts of cooling air.

[0032] Fig. 5 illustrates a second embodiment of an inventive seal assembly which is consists of a laminated connector plate 8 according to the present invention. As seen in the Fig. 5 the connector plate 8 consists of three different layers with layer 9 of a base material, a layer 10 of a thermal insulating material and a layer 11 of a base material or made of an oxide resistant material The connector plate 8 is bended around and welded to the two sides of an E-seal 12. The E-seal 12 consists as well of Inconel 718. The E-seal 12 can be provided with or without cooling holes 13. For the flow of cooling holes.

[0033] Fig. 6 shows a third embodiment of an inventive seal assembly 5. It consists of two layers and inner and on outer layer of E-seals 12 between which a layer 10 of thermal insulating material.

[0034] While our invention has been described by an example, it is apparent that other forms could be adopted by one skilled in the art. Accordingly, the scope of our invention is to be limited only by the attached claims.

REFERENCE NUMBERS

[0035] 1 Combustion chamber

[0036] 2 Combustor liner segment

[0037] 3 Clamp strip

[0038] 4 Casing

[0039] 5 Seal, seal assembly

[0040] 6 Cooling holes

[0041] 7 Spring side support

[0042] 8 Connector plate

[0043] 9 Layer of a base material

[0044] 10 Layer of a thermal insulating material

[0045] 11 Layer of a base material or made of an oxide resistant material

[0046] 12 E-seal

[0047] 13 Cooling hole

[0048] A Side of the seal assembly exposed to the hot gas path

[0049] B Side of the seal assembly exposed to the cooling medium

[0050] t_1 Temperature of hot surface of Inconel 718 outer ply

[0051] t_2 Temperature of cool surface of Inconel 718 outer ply / of hot surface of Nextel

[0052] t_3 Temperature of cool surface of Nextel / of hot surface of Inconel 718 inner ply

[0053] t_4 Temperature of cool surface of Inconel 718 inner ply